INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 12, No. 6, p. 174-182, 2018

RESEARCH PAPER OPEN ACCESS

Effect of brackish water on the production of garlic and soil properties

Amar Iqbal Saqib, Khalil Ahmed*, Abdul Rasul Naseem, Ghulam Qadir, Muhammad Qaisar Nawaz, Zaheen Manzoor, Muhammad Ilyas

Soil Salinity Research Institute (SSRI), Pindi Bhattian, Pakistan

Key words: Garlic, irrigation water, EC_{iw}, RSC, growth.

http://dx.doi.org/10.12692/ijb/12.6.174-182 Article published on June 14, 2018

Abstract

Agricultural user must rely on poor quality water to suuply food and fiber for a growing population. Therefore, exploring the salinity tolerance potential of high value marketable horticultural crops is justification for consideration of such species in systems as they require high inputs of water. Hence,a two years study was conducted to evaluate the tolerance of garlic plant towards combined effect of EC_{iw} and RSC of irrigation water on its vegetative growth, yield and yield components. Cloves of garlic were planted in cemented blocks with seven treatments having different levels of EC_{iw} (2 and 3.5dS m^{-1}) and RSC (2.50, 3.75 and5 me L^{-1}). All there corded attributes like plant height (8.26%), number of leaves plant^{-1}(16.06 %), biomass yield(13.69 %), bulb weight(8.75 %), bulb diameter (10.92%) and bulb yield (13.30%) significantly decreased in T_7 (ECiw = 3.5 dS m-1 + SAR = 5 me L-1)in comparison with control. Also this Higher level of EC_{iw} and RSC as in T_7 (EC_{iw}= 3.5dS m^{-1} + SAR = 5 me L^{-1}) showed more detrimental affects on soil properties and proved more hazardous for garlic plant.

* **Corresponding Author:** Khalil Ahmed ✉ khalilahmeduaf@gmail.com

Introduction

Currently world population growth rate is 2 percent and it is estimated that after every 35 years water need will be doubled to the present. (Naeimi and Zehtabian, 2011). Therefore in arid to semi arid regions not land but shortage of good quality water will limits agricultural production.

Situation is getting worse as good quality irrigation water supplies are expected to decrease in future and new water resources will not keep pace with the increasing water demands from nonagricultural sectors (Ostera, 1994).

In Pakistan, 86 million acre foot (MAF) of river water is diverted into irrigation canals (GOP, 2002). Due to increased cropping intensity, more agricultural demand and drought condition, seemingly enormous amount of irrigation water could not keep pace with the crop water requirement. This necessitated the development of unconventional water sources in addition to the efficient use of existing ones. Therefore, ground water is being pumped to meet crop water requirement. To overcome this problem, inadequate supplies of water can be augmented with tube well water, however, 70-80 % tube wells pumped the water of poor quality (Latif and Beg 2004; Murtaza *et al.* 2009). So it is imperative that agricultural user must rely on this poor quality water to suuply food and fiber for a growing population (Elagib, 2014; Guo *et al.*, 2014). Therefore, exploring the salinity tolerance potential of high value marketable horticultural crops is justification for consideration of such species in systems as they require high inputs of water.

Garlic (*Allium sativum* L.) belongs to the family Alliaceae and is the 2nd most extensively grown bulb crop after onion (Hamma *et al.,* 2013). In recent years, cash value of the garlic crop has augmented greatly in the whole world. It is cultivated for domestic use as well as for export purpose by many peasant farmers in many parts of countries (Getachew and Asfaw, 2000). In pakistan during 2011-12, garlic production was 1698.1 tonnes with a total area of 172.4 thousand hectare (GOP, 2012).

Threshold salinity of garlic is 3.9 dS m^{-1} and 50% yield reduction occur at 7.4 dS m^{-1} (Francoi, 1994). Amorim *et al.* (2002) studied the effect of five different salinity levels of brackish water ranges from 0.6 to 3.0 dS m^{-1} on growth and yield characteriscts of garlic plant at 30, 60, 90 and 120 days after planting. They reported that initial growth up to 30 days and bulb formation stage of garlic plants was relatively tolerant to salinity. However last 30 days of crop cycle were most sensitive to salinity. El-Fadel and Mohamed (2013) studied the effect of saline water i.e 1500, 2500 and 3500 mg L^{-1} on two garlic varieties namely Sids 40 and Baladi. They founds that Baladi was salt tolerant as compared to Sids 40 and irrigation with brackish water of 3500 mgL^{-1} significantly decresed the vegetative growth and yield of both tested cultivars. Similarly, Mangal *et al.* (1990) reported that salinity tolrence of garlic plants depends upon its genotype and 50% yield reduction occurs at 5.60 to 7.80 dS m^{-1}.Al-Safadi and Faoury (2004) evaluated the salinity tolerance of 25 garlic cultivars at five differnts culture media containing different concentralions of NaCI and CaCl, (0 and 0, 17 and 9, 34 and 18,51 and 27,68 and 36 mM, respectively). They reported the Klsswany and Hungary as most tolerant cultivars to salinity however high concentrations of the two salts resulted a significant decreased in vegetitave growth. Shiyab (2017) quantified the effect of 0, 50, and 100 mMNaCl on two marketable garlic cultivars namely Jordan and California. He reported that fresh weight reduced to 10 and 14% in cv. Jordan and California respectively when exposed to 100 mM of NaCl as compared to the control.

So keeping the above facts in consideration, current study was planned to investigate the salinity/sodicity tolerance potential of garlic when irrigated with brackish water of various salinity and sodicity levels.

Materials and method

A two years study was conducted from 2012 to 2014 at Soil Salinity Research Institute, Pindi Bhattian, Pakistan to evaluate the effects of differnt EC_{iw} and RSC levels of irrigation water on garlic plant. Treatment used were; T_1 = Control (Fit water), T_2= EC_{iw}2.0 dS m^{-1}& RSC 2.50 me L^{-1}, T_3=EC_{iw} 2.0 dS m^{-1}& RSC 3.75 me L^{-1},T_4=EC_{iw} 2.0 dS m^{-1}& RSC 5.00 me L^{-1}, T_5=EC_{iw} 3.5 dS m^{-1}& RSC 2.50 me L^{-1}, T_6=EC_{iw} 3.5 dS m^{-1}& RSC 3.75 me L^{-1} and T_7=EC_{iw} 3.5 dS m^{-1}& RSC 5.00 me L^{-1}. A normal soil was selected and analyzed for EC_e(2.04 dS m^{-1}), pH_s (7.90), SAR (8.60 mmol $L^{-1})^{1/2}$andtexture(loam). Collected soil was filled in cemented blocks (180 cm length×120 cm wide×90cm height). Cloves of garlic cultivar (Lehsin Gulabi) were planted in 1st week of November, keeping plant x plant and row x row distance of 10 and 20 cm respectively. Experimental design was Completely Randomized Design (CRD) having three replications. The recommended dose of NPK was used @ 125-60-60 kg ha^{-1} in the form of urea, single super phosphate (SOP) and sulphate of potash (SOP) respectively. Half nitorogen and full dose of phosphorus and potash was applied at sowing time while remaing half nitrogen was applied after 50 days of sowing. Desired combination of EC_{iw} and RSC of irrigation water were developed artificially in each season by using salts of $CaCl_2$, NaCl, $MgSO_4$ and Na_2SO_4, as calculated by quadratic equation (Ghafoor *et al.,* 1988). Measured quantity of irrigation @ 182 L/ block was applied according to treatments plan and crop requirement. All the standard agronomic management practices were adopted. Crop was harvested at physiological maturity and following growth and yield parameters were recorded: plant height (cm), number of leaves $plant^{-1}$, biomass yield (t. ha^{-1}), bulb weight (g), bulb diameter (cm) and bulb yield (t. ha^{-1}). The data collected was subjected to analysis of variance according to Steel *et al.* (1997) to calculate the least significant differences (LSD) among treatments means at 5% probability level using STATISTIX 8.1 package software.

Results

First season (2012-13)

Results of all the studied parameters during first season (2012-13) exhibited that EC_{iw} and RSC had negative impact on growth and yield characteristics of garlic plant.

Table 1. Effect of different levels of EC (dS m^{-1}) and RSC (me L^{-1}) of irrigation water on plant height (cm), number of leaves $plant^{-1}$ and biomass yield (t.ha^{-1}) of garlic (2012-13).

Treatments EC: RSC	Plant Height(cm)	Percent decrease	Leaves$Plant^{-1}$	Percent decrease/ incease over control	Biomass (t.ha^{-1})	Percent decrease/ increase over control
T_1(Fit water)	72.67 A	-	10.33 AB	-	15.85 A	-
T_2 (2.0:2.50)	71.00 AB	2.30	10.67 A	3.29	16.09 A	1.51
T_3(2.0:3.75)	72.00 A	0.92	10.00 AB	3.19	15.98 A	0.82
T_4(2.0:5.00)	70.67 AB	2.75	11.00 A	6.48	15.63 A	1.39
T_5(3.5:2.50)	71.00 AB	2.30	10.33 AB	-	15.98 A	0.82
T_6(3.5:3.75)	68.33 BC	5.97	8.67 B	16.06	14.42 B	9.02
T_7(3.5:5.00)	66.67 C	8.26	8.67 B	16.06	13.68 C	13.69

Different letters in the same column indicate significant differences by LSD at $P \leq 0.05$.

Data presented in (Table 1) showed that maximum plant height (72.67 cm) was obtained in T_1 (fit water) however differences between plant height of treatments T_1, T_2, T_3, T_4 and T_5 were insignificant ($p < 0.05$). But at the same time plant height significantly decresed with highest level of EC_{iw} and RSC and minimum plant height (66.67 cm) was observed in T_7 (EC_{iw} 3.5 dS m^{-1}& RSC 5 me L^{-1}).With respect to number of leaves $plant^{-1}$, maximum number of leaves (10.67) were noted in T_4 (EC_{iw} 2 dS m^{-1}& RSC 5 me L^{-1}),however, statistically ($p < 0.05$) it was non significant with control and lower level of EC_{iw} upto 2 dS m^{-1}(Table 1). But with increasing levels of EC_{iw} significant decrease in number of leaves was observed and minimum number of leaves (8.67) were observed in T_7 with EC_{iw} 3.5 dS m^{-1}& RSC 5 me L^{-1} of irrigation water. Similar trend was observed in biomass yield(Table 1), T_2 produces maximum biomass yield of16.09 t.ha^{-1} which was at par with control and lower level of EC_{iw}upto 2 dS m^{-1}. However increasing levels of EC_{iw} and RSC significantly decreses the biomass yield and minimum biomass yield (13.68 t.ha^{-1}) was recoreded at highest intensities of EC_{iw} 3.5 dS m^{-1}& RSC 5 me L^{-1}.

Data in Table 2 depicted that slightly brackish water had positive effect on yield and yield attributes of garlic during first season, however with increasing levels of EC_{iw}& RSC yield is significantly affected. Maximum bulb weight (20.01 g) was obtained in T_2 which was statistically at par with control and lower level of EC_{iw}upto 2.5 dS m^{-1}.

Table 2. Effect of different levels of EC (dS m^{-1}) and RSC (me L^{-1}) of irrigation water on bulb weight (gm), bulb diameter (cm) and bulb yield (t.ha^{-1}) of garlic (2012-13).

Treatments EC: RSC	Bulb weight (gm)	Percent decrease/ increase over control	Bulb diameter (cm)	Percent decrease/ increase over control	Bulb yield (t. ha^{-1})	Percent decrease/ increase over control
T_1(Fit water)	19.78 AB	-	04.03 A	-	9.10 A	-
T_2 (2.0:2.50)	20.01 A	1.16	04.02 A	-	9.13 A	0.32
T_3(2.0:3.75)	19.96 AB	0.91	03.95 AB	1.98	8.98 A	1.32
T_4(2.0:5.00)	19.79 AB	0.05	03.89 AB	3.47	8.90 A	2.20
T_5(3.5:2.50)	19.68 B	0.50	03.81 BC	5.46	8.87 A	2.53
T_6(3.5:3.75)	18.76 C	5.16	03.65 CD	9.43	8.28 B	9.01
T_7(3.5:5.00)	18.05 D	8.75	03.59 D	10.92	7.89 C	13.30

Different letters in the same column indicate significant differences by LSD at $P \leq 0.05$.

At higher level of EC_{iw} a significant decrease in bulb weight was recorded and minimum bulb weight (18.05) was observed with EC_{iw} 3.5 dS m^{-1}& RSC 5 me L^{-1}. Same tendency was observed in bulb diameter (Table 2), data revealed that maximum bulb diameter (4.03 cm) was noted in control (T_1) which was statistically ($p < 0.05$) similar to T_2, T_3, T_4 and T_5 while further increased in salinity significantly decreses the bulb diameter and minimum bulb diameter (3.59 cm) was recorded with EC_{iw} 3.5 dS m^{-1}& RSC 5 me L^{-1}. Results regarding bulb yield (Table 2) indicated that peak value for bulb yield (9.13 t ha^{-1}) was recordedinT_2which was statistically similar to T_1, T_3, T_4 and T_5. While highest level of salinity i.eEC_{iw} 3.5 dS m^{-1}& RSC 5 me L^{-1} produces minimum bulb yield of 7.89 t. ha^{-1}.

Table 3. Effect of different levels of EC (dS m^{-1}) and RSC (me L^{-1}) of irrigation water on plant height (cm), number of leaves $plant^{-1}$ and biomass yield (t.ha^{-1}) of garlic (2013-14).

Treatments EC: RSC	Plant Height (Cm)	Percent decrease/ increase over control	Leaves $Plant^{-1}$	Percent decrease/ increase over control	Biomass (t.ha^{-1})	Percent decrease /increase over control
T_1(Fit water)	70.00 A	-	11.67 A	-	15.21 A	-
T_2 (2.0:2.50)	68.00 AB	2.85	10.33 AB	11.48	14.43 B	5.13
T_3(2.0:3.75)	67.33 B	3.81	09.67 BC	17.14	13.49 C	11.31
T_4(2.0:5.00)	64.00 C	8.57	09.00 BC	22.88	11.52 D	24.26
T_5(3.5:2.50)	67.00 B	4.28	09.00 B C	22.88	11.71 D	23.01
T_6(3.5:3.75)	62.00 CD	11.43	08.00 C	31.45	09.46 E	37.80
T_7(3.5:5.00)	60.33 D	13.81	08.00 C	31.45	08.22 F	45.96

Different letters in the same column indicate significant differences by LSD at $P \leq 0.05$.

Second season (2013-14)

A quick glance on data of second year showed that there is negative correlation between growth characteristics of garlic plants and increasing levels of water salinity (Table 3). In T_1 (control) maximum plant height was obsereved which decreased significantly with increasing salinity and sodicity levels i.e.13.81% reduction over control was observed at highest intensities of EC_{iw} 3.5 dS m^{-1}& RSC 5 me L^{-1}. Data regarding number of leaves $plant^{-1}$indicated a dwindling trend with increasing EC_{iw}& RSC of irrigation water and produced more deleterious effect in $T_6$and $T_7$with 31.45 % reduction over the control(Table 3). Biomass yield also followed the same trend pertaining to deleterious effect of salinity, differences among the brackish water treatments was statsistically significant and magnitude of reduction was more evidenced in T_7(Table 3). Compared with control biomass decrease of 37.80 and 45.96% was observd in T_6 and T_7 respectively.

Table 4. Effect of different levels of EC (dS m^{-1}) and RSC (me L^{-1}) of irrigation water on bulb weight (gm), bulb diameter (cm) and bulb yield (t.ha^{-1}) of garlic (2013-14).

Treatments EC: RSC	Bulb weight (gm)	Percent decrease/ increase over control	Bulb diameter (cm)	Percent decrease/ increase over control	Bulb yield (t. ha^{-1})	Percent decrease/ increase over control
T_1(Fit water)	19.21 A	-	03.83 A	-	8.72 A	-
T_2 (2.0:2.50)	18.81 B	2.08	03.65 B	4.70	8.39 B	3.78
T_3(2.0:3.75)	17.40 C	9.42	03.47 BC	9.40	7.58 C	13.07
T_4(2.0:5.00)	15.70 D	18.27	03.18 D	16.97	6.63 D	23.96
T_5(3.5:2.50)	15.81 D	17.70	03.39 C	11.49	6.79 D	22.13
T_6(3.5:3.75)	13.37 E	30.40	02.91 E	23.76	5.41 E	37.96
T_7(3.5:5.00)	12.98 F	32.43	02.78 E	27.41	4.75 F	45.52

Different letters in the same column indicate significant differences by LSD at $P \leq 0.05$.

Results regarding bulb weight showed that T_1 produces significantly ($p < 0.05$) greater (19.21 g) bulb weight that decreased gradually with increasing EC_{iw} and RSC, acquiring to a minimum value of (12.98 g) in T_7(Table 4). Bulb diameter also decresed consistently and significantly by the increase in EC_{iw}& RSC of irrigation water. Highest reduction of 27.41% in bulb diameter was noted in T_7over control(Table 4). There was also continuous decreased in bulb yield with increasing levels of EC_{iw} and RSC of irrigation water. Maximum bulb yield (8.72 t ha^{-1}) was produced by T_1 (control) which dwindled to (4.75 t. ha^{-1}) with highest level of salinity i.eEC_{iw} 3.5 dS m^{-1}& RSC 5 me L^{-1}. When compared with the control yield reduction of 3.78%, 13.07%, 23.96%, 22.13%, 37.96% and 45.52% was noted for T_2, T_3 T_4, T_5, T_6 and T_7 respectively(Table 4).

Soil properties

Data of soil analysis showed that continuous use of brackish water negatively affect the soil chemical properties and effect was more noticeable in second season(Table 5 & 6).

Table 5. Effect of different levels of EC (dS m^{-1}) and RSC (me L^{-1}) of irrigation water on soil chemical properties (2012-13).

Treatments EC: RSC	pH	Percent decrease/ increase over initial value	EC_e(dS m^{-1})	Percent decrease/ increase over initial value	SAR $(mmolL^{-1})^{1/2}$	Percent decrease/ increase over initial value
T_1(Fitwater)	7.92	0.25	2.10	2.94	8.7	1.16
T_2 (2.0:2.50)	7.98	1.01	3.08	50.98	10.44	21.39
T_3(2.0:3.75)	8.10	2.53	3.03	48.52	12.94	50.46
T_4(2.0:5.00)	8.23	4.17	3.05	49.50	15.08	75.34
T_5(3.5:2.50)	8.05	1.89	3.87	89.70	11.24	30.69
T_6(3.5:3.75)	8.19	3.67	3.95	93.62	15.88	84.65
T_7(3.5:5.00)	8.35	5.69	3.92	92.15	17.56	104.18

Soil salininty indicators like pH_s, EC_e and SAR increased linearly with increasing levels of EC_{iw}& RSC of irrigation water and maximum increase was recorded with highest level of salinity inT_7 i.eEC_{iw} 3.5

dS m^{-1}& RSC 5 me L^{-1}.When compared with the initial value, a increase of 5.69%, 92.15%, 104.18%, was observed in pH_s, EC_e and SAR respectively in T_7 during the first season (2012-13). While at the end of study in 2013-14 this increased was 10%, 241.66%, 324.18%, inpH, EC_e and SAR respectively in T_7(Table 5).

Discussion

Growth and development of various plant species depends on its mechanism or resistance to grow under unfavorable environment (Zivkovic, 2007). Use of brackish water has negative effect on soil–water–plant relations, generally suppress the normal physiological activities and productivity of the crops (De Pascale *et al.*, 2013; Plaut*et al.*, 2013). Vegetables are consider sensitive to moderatively sensitive against salinity (Shannon and Grieve, 2000).Results of our study showed that applied levels of EC_{iw} and RSC of irrigation water were found to induce a severe diminution in growth and yield characteristics of garlic and deleterious effects were more evident with highest level of salinity and sodicityi. eEC_{iw} 3.5 dS m^{-1}& RSC 5 me L^{-1}.Plant height decreased linearly with increasing levels of EC_{iw} and RSC of irrigation water and reduction was more pronounced in second season ranges from 2.85% to 13.81% over the control. Irrigation with brackish water increased the root zone soil salinity.

Table 6. Effect of different levels of EC (dS m^{-1}) and RSC (me L^{-1}) of irrigation water on soil chemical properties (2013-14).

Treatments EC: RSC	pH	Percent decrease/ increase over initial value	EC_e(dSm^{-1})	Percent decrease/ increase over initial value	SAR $(mmolL^{-1})^{1/2}$	Percent decrease/ increase over initial value
T_1(Fit water)	7.95	0.63	2.19	7.35	8.78	2.09
T_2 (2.0:2.50)	8.14	3.03	4.67	128.92	14.76	71.62
T_3(2.0:3.75)	8.3	5.06	4.75	132.84	23.44	172.55
T_4(2.0:5.00)	8.57	8.48	4.71	130.88	30.52	254.88
T_5(3.5:2.50)	8.21	3.92	6.85	235.78	16.28	89.30
T_6(3.5:3.75)	8.47	7.21	6.89	237.74	29.84	246.97
T_7(3.5:5.00)	8.69	10.00	6.97	241.66	36.48	324.18

This stunted palnt growth in hyper saline environment may be corelated to more negative osmotic potential (Tester & Davenport, 2003) nutritional imbalance, uptake of toxic (Na^+ and Cl^-), water deficit, alteration in certain hormonal activities, oxidative stress andretarding the mobilization rate of metabolites (Moosavi *et al.,* 2013).Stunted plant growth as a result of saline conditions has been stated in several plant species (Al-Khateeb, 2007; Turan *et al.*, 2009) which reinforced the findings of this study.

Number of leaves $plant^{-1}$ and biomass yield were also decreased with increasing salinity and sodicity of brackish water which could be attributed to that saline conditions adversely affect water absorption due to a reduction in cellular permeability (Mansour and Stadelmann, 1994), leading to more negative water potential in plant and ultimately reduces the meristematic activity and cell elongation (Dorgham, 1991) and eventually reduces the number of leaves and biomass. In most of cases soil solution salinity of 1.9 dS m^{-1} is sufficient to cause significant decrease in biomass (Zeng & Shannon, 2000).Reduction in biomass due to salt stress was also previously reported by many researchers (Mensah *et al.*, 2006; Sadat-Noori, 2008)which are in agreement with these results.

It is clear from yield data that root zone salinity had meaningfully ($p > 0.05$) adverse effect on bulb weight and diameter and reduction was more remarkable with increasing EC_{iw} and RSC particularly at higher level i.eEC_{iw} 3.5 dS m^{-1}& RSC 5 me L^{-1}. Salinity resistance at early growth phase is necessary for development of vigorous plants which can tolerate toxic salt concentration at later growth stages. The reduced bulb weight and diameter could be ascribed to the toxic concentration of Na^+ and Cl^- in cellular tissue which can cause changes in plasma membrane structure (Wang *et al.*,1997) damages the cell metabolism, reduces the activities of photosynthetic enzymes like Rubisco and PEP-carboxylase, prevents protein synthesis (Yang *et al.*, 2002) and subsequently the decreases thebulb weight of garlic. Furthermore bulb yield was substantially lowered with high levels of salinity and sodicity of irrigation water. Different plant physiological processes are disturbed by high salinity (Taffouo *et al.*, 2004) thickness of the assimilate conducting canal is decreased (Aldesuquy and Ibrahim, 2001) and leaves start acting as sinks instead of sources (Arbona *et al.,* 2005).

This suppress the movement of assimilate to the developing reproductive organs and thus can be held responsible for the observed decrease in the bulb yield. These results are in agreement with earlier findings (Andriolo *et al.* 2005; Unlukara *et al.*, 2008; Kim *et al.*, 2016). They reported that decrease in crop yield with increase in salinity of irrigation water was due to disturbances in physiological and biochemical activities under saline conditions.

Soil analysis data showed that soil chemicals properties were negetaively affected by use of brackish water. Sharp increase in soil pH_s, EC_e and SAR was due to accumulation of more soluble salts and Na^+ which deteriorate the soil properties and negatively affect the crop production (Murtaza *et al.* 2009).

Conclusion

The findings of this study elucidated that cumulative stress of EC_{iw} and RSC of irrigation Medicago sativa reduces the growth, yield and yield components of garlic plant as compared to control. Magnitude of reduction increased with increasing levels of salinity and sodicity and T_7 (EC_{iw} = 3.5 dS m^{-1} and RSC = 5.0 me L^{-1}) proved more hazardous than all other treatments.

Therefore further investigations are recommended with reference to efficient utilization of brackish water for fruitful commercial cultivation of garlic according to different $EC_{iw}$and RS Cvalues.

Refrences

AI-Safadl B, Faoury H. 2004. Evaluation of salt tolerance in Garlic (Allium sativum L.) cultivars using in vitro techniques. Advances in Horticultural Science **18(3),** 115-120.

Aldesuquy HS, Ibrahim AH.2001. Interactive effect of seawater and growth bio-regulators on water relations, absicisic acid concentration and yield of wheat plants. Journal of Agronomy and Crop Science **187,**185–193. https://doi.org/10.1046/j.1439-037x.2001.00522.x

Al-Khateeb SA.2007. Effect of calcium/sodium ratio on growth and ion relations of Alfalfa (Medicago sativa L.) seedling grown under saline condition. Journal of Agronomy**5,**175-181. https://doi.org/10.3923/ja.2006.175.181

Amorim JR, Fernandez PD, Gheyi HR, Azevedo NC. 2002. Effect of irrigation water salinity and its mode of application on garlic growth and production (in French). Pesquisa Agropecuária Brasileira **37,** 167-76.

Andriolo JL, da Luz GL, Witter MH, Godori RS, Barros GT, Bortolotto OC. 2005. Growth and yield of lettuce plants under salinity. Horticultura Brasileira **23,** 931–934. http://dx.doi.org/10.1590/S010205362005000400014

Arbona V, Marco AJ, Ijlesias DJ, Lopez-Climent TM, Gomez-Coudenas A. 2005. Carbohydrate depletion in roots and leaves of salt stressed potted Citrus clementina L. Plant Growth Regulator**46,**153–160. http://dx.doi.org/10.1007/s10725-005-7769-z

De Pascale, Orsini SF, Pardossi A. 2013. Irrigation water quality for greenhouse horticulture. In Good Agricultural Practices for Greenhouse Vegetable Crops; FAO Plant Production and Protection Paper 217; Food and Agriculture Organization of the United Nations: Rome, Italy, 2013; 169–204 P.

Dorgham EA.1991. Effect of water stress, irradiation and nitrogen fertilization on grain filling, yield and quality of certain wheat cultivars. PhD Thesis.Ain Shams University of Cairo, Egypt.

Elagib NA. 2014. Development and application of a drought risk index for food crop yield in Eastern Sahel. EcologicalIndicators**43,** 114–125. http://dx.doi.org/10.1016/j.ecolind.2014.02.033

Francois LE. 1994. Yield and quality response of salt-stressed garlic. Horticultural Science,**29,** 1314-1317.

Getachew T, Zellek A. 2000. Achievements in shallot and research. Report.No. 36 Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia.

Ghafoor A, Aziz T, Abdullah M.1988. Dissolution of gypsum size grades in synthetic saline solutions. Journal of Agricultural Research.**26,**289-294.

Government of Pakistan. 2002. Pakistan Statistics Year Book 2002. Federal Bureau of Statistics Division, Government of Pakistan, Islamabad, Pakistan.

Government of Pakistan. 2012. Agriculture Statistics of Pakistan, Ministry of food and agriculture Islamabad.

Guo W, Fu Y, Ruan B, Ge H, Zhao N. 2014. Agricultural non-point source pollu-tion in the Yongding River Basin. Ecological Indicators **36,** 254–261. http://dx.doi.org/10.1016/j.ecolind.2013.07.012

Hamma IL, Ibrahim U, Mohammed AB. 2013. Growth, yield and economic performance of garlic (Allium sativum L.) as influenced by farm yard manure and spacing in Zaria, Nigeria. Journal of Agricultural Economics and Sustainable Development **2,** 1-5.

Kim H, Jeong H, Jeon J, Bae S. 2016. Effects of Irrigation with Saline Water on Crop Growth and Yield in Greenhouse Cultivation. Water, **127,** 2-9. https://doi.org/10.3390/w8040127

Latif M, Beg A. 2004. Hydrosalinity issues, challenges and options in OIC member states. In Proceedings of the International Training Workshop on Hydrosalinity Abatement and Advance Techniques for Sustainable Irrigated Agriculture, 1–14 p. September 20–25, 2004. Lahore, Pakistan: PCRWR.

Mangal JL, Singh RK, Yadav AC, Lal S, Pandey UC. 1990. Evaluation of garlic cultivars for salinity tolerance. Journal of Horticultural Sciences **65,** 657-658. https://doi.org/10.1080/00221589.1990.11516105

Mansour MMF,Stadelmann EJ.1994. NaCl induced changes in protoplasmic characteristics of Hordeum vulgare cultivars differing in salt tolerance. Physiologia Plantarum. **31,**29–41. https://doi.org/10.1111/j.1399-3054.1994.tb02965.x

Mensah JK, Akomeah PA, Ikhajiagbe B, Ekpekurede EO.2006. Effects of salinity on germination, growth and yield of five groundnut genotypes. African Journal of Biotechnology **5,**1973-1979.

Moosavi SG, Seghatoleslami MJ, Jouyban Z, Javadi H.2013. Effect of salt stress on germination and early seedling growth of Nigella sativa L. International Journal of Tradiional Herb and Medicine,45-48.

Murtaza G, Ghafoor A, Owens G, Qadir M, Kahlon U. 2009. Environmental and economic benefits of saline-sodic soil reclamation using low quality water and soil amendments in conjunction with a rice-wheat cropping system. Journal of Agronomy and Crop Sciences, **195,** 124–36. https://doi.org/10.1111/j.1439-037X.2008.00350.x

Naeimi M, Zehtabian G. 2011. The review of saline water in desert management. International Journal of Environmental Science and Development**2,** 474-478. http://dx.doi.org/10.7763/IJESD.2011.V2.172

Nashwa I, Fadel AE, Mohamed WH. 2013. Response of Two Garlic Cultivars to Foliar Nutrition under Irrigation with Saline Water. Egypt Journal of Soil Science **53,** 207-220. http://dx.doi.org/10.21608/EJSS.2013.163

Ostera JD. 1994. Review article Irrigation with poor quality water. Agriculture Water Management**25,** 271-29. https://doi.org/10.1016/0378-3774(94)90064-7

Plaut Z, Edelstein M, Ben-Hur M.2013. Overcoming salinity barriers to crop production using traditional methods. Critical Review in Plant Science **32,**250–291. https://doi.org/10.1080/07352689.2012.752236

Safwan S. 2017. Response of garlic callus to salt level. Academia Journal Biotechnology **5(1),** 6-11. http://dx.doi.org/10.15413/ajb.2017.0126

Shannon MC, Grieve CM. 2000. Options for using low-quality water for vegetable crops. Horticultural Science **35(6),**1058- 1062. http://dx.doi.org/10.1016/S0304-4238(98)00189-7

Steel RGD, Torrie JH, Dickey DA. 1997. Principles and Procedures of Statistic: A Biometrical Approach. 3rd edition, 400-428 p. McGraw Hill book Co. Inc. New York.

Taffouo VD, Kenne M, Fokam TR, Fotsop WO, Fonkou T, Vondo Z, Amougou AKOA.2004. Reponse au stress salin chez cinqespeces de Legumineuses. Agronomy Africa**16,** 33-44. http://dx.doi.org/10.4314/aga.v16i1.1638

Tester M, Davenport R. 2003. Na+ tolerance and Na^+ transport in higher plants. Annal of Botany**91,** 503-527. https://doi.org/10.1093/aob/mcg058

Turan MA, Hassan A, Taban N, Taban S.2009. Effect of salt stress on growth, stomatal resistance, proline and chlorophyll concentrations on maize plant. Africa Journal of Agricultural Research **4.**893-897.

Unlukara A, Cemek B, KaramanS, Ersahin S. 2008. Response of lettuce (Lactuca sativa var. Crispa) to salinity of irrigation water. New Zealand Journal of Crop and Horticultural Science**36,** 263–271. https://doi.org/10.1080/01140670809510243

Wang BS, Zhao KF.1997. Changes in Na and Ca concentrations in the apoplast and symplast of etiolated maize seedlings under NaCl stress. ActaAgronomicaSinica.23, 27-33.

Yang YH, Sun QY, Shen H.2002. Salt tolerance and injury of plants (in Chinese).Biology Teaching **27,**12-22.

Zeng L, Shannon MC, Lesch SM. 2001. Timing of salinity stress affects rice growth and yield components. Agriculture Water Management**48,** 191-206. http://dx.doi.org/10.1016/S0378-3774(00)00146-3.

zivkovic S, Devic M, Filipovic B, Giba Z, Grubisic D. 2007. Effect of NaCl on seed germination in some Centaurium Hill. species (Gentianaceae). Archives of Biological Sciences **59,**227-231. http://dx.doi.org/10.2298/ABS0703227Z